

Study of the Radical Chain Mechanism of Hydrocarbon Oxidation for in Situ Combustion Process

Ushakova A., Zatsepin V., Varfolomeev M., Emelyanov D.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2017 Alexandra Ushakova et al. Despite the abundance of in situ combustion models of oil oxidation, many of the effects are still beyond consideration. For example, until now, initial stages of oxidation were not considered from a position of radical chain process. This is a serious difficulty for the simulation of oil recovery process that involves air injection. To investigate the initial stages of oxidation, the paper considers the sequence of chemical reactions, including intermediate short-living compounds and radicals. We have attempted to correlate the main stages of the reaction with areas of heat release observed in the experiments. The system of differential equations based on the equations of oxidation reactions was solved. Time dependence of peroxides formation and start of heat release is analytically derived for the initial stages. We have considered the inhibition of initial oxidation stages by aromatic oil compounds and have studied the induction time in dependence on temperature. Chain ignition criteria for paraffins and crude oil in presence of core samples were obtained. The calculation results are compared with the stages of oxidation that arise by high-pressure differential scanning calorimetry. According to experimental observations we have determined which reactions are important for the process and which can be omitted or combined into one as insignificant.

<http://dx.doi.org/10.1155/2017/2526596>

References

- [1] P. S. Sarathi, In-Situ Combustion Handbook-Principles and Practices, BDM Petroleum Technologies, 1999.
- [2] A. T. Turta, S. K. Chattopadhyay, R. N. Bhattacharya, A. Condrachi, and W. Hanson, "Current status of commercial in situ combustion projects worldwide, " Journal of Canadian Petroleum Technology, vol. 46, no. 11, pp. 8-14, 2007.
- [3] H. J. Remy, "In-situ combustion, " in Proceedings of the 8th World Petroleum Congress, Discussion Symposium, USSR, Moscow, Russia, June 1971.
- [4] D. Gutiérrez, R. J. Miller, A. R. Taylor, B. P. Thies, and V. K. Kumar, "Buffalo field high-pressure-air-injection projects: technical performance and operational challenges, " SPE Reservoir Evaluation and Engineering, vol. 12, no. 4, pp. 542-550, 2009.
- [5] Y. G. Mamedov and A. A. Bokserman, "Application of improved oil recovery in Soviet Union, " in Proceedings of the Enhanced Oil Recovery Symposium, 24162-MS SPE, Tulsa, Okla, USA, April 1992.
- [6] C. Chu, "A study of fireflood field projects (includes associated paper 6504), " Journal of Petroleum Technology, vol. 29, no. 2, pp. 111-120, 1977.
- [7] T. M. Counihan, "A successful in-situ combustion pilot in the Midway-Sunset Field, California, " in Proceedings of the SPE California Regional Meeting, SPE 6525, Bakersfield, Calif, USA, April 1977.

- [8] A. N. Shandrygin and A. Lutfullin, "Current status of enhanced recovery techniques in the fields of Russia, " in Proceedings of the SPE Annual Technical Conference and Exhibition (ATCE '08), pp. 1929-1946, Denver, Colo, USA, September 2008.
- [9] D. G. Mallory, I. I. Abu, K. Fraassen, M. G. Ursenbach, R. G. Moore, and S. A. Mehta, "Accelerating Rate Calorimetry Tests West Salym Oil & Core in Contact with Air, " 2011.
- [10] E. T. Denisov, Kinetics of Homogeneous Chemical Reactions, High School, Moscow, Russia, 1973 (Russian).
- [11] N. P. Freitag, "Chemical-reaction mechanisms that govern oxidation rates during in-situ combustion and high-pressure air injection, " SPE Reservoir Evaluation & Engineering, vol. 19, no. 4, 2016.
- [12] N. M. Emanuel, "Present state of the theory of chain reactions in the liquid phase oxidation of hydrocarbons, " in Proceedings of the 7th World Petroleum Congress, Mexico City, Mexico, April 1967.
- [13] K. U. Ingold, "Oxidation of organic compounds, " in Oxidation of Organic Compounds, vol. 75 of Advances in Chemistry, chapter 23, pp. 296-305, American Chemical Society, 1968.
- [14] N. Semenov, "Advances of chemical kinetics in the Soviet Union, " Nature, vol. 151, no. 3824, pp. 185-187, 1943.
- [15] V. A. Klinchev, V. V. Zatsepin, A. S. Ushakova, and S. V. Telyshev, "Laboratory studies and implementation of in-situ combustion initiation technology for air injection process in the oil reservoirs, " Tech. Rep. SPE-171244, 2014.
- [16] J. G. Burger and B. C. Sahuquet, "Chemical aspects of insitu combustion-heat of combustion and kinetics, " Society of Petroleum Engineers Journal, vol. 12, no. 5, pp. 410-422, 1972.
- [17] B. Sequera, R. G. Moore, S. A. Mehta, and M. G. Ursenbach, "Numerical simulation of in-situ combustion experiments operated under low temperature conditions, " Journal of Canadian Petroleum Technology, vol. 49, no. 1, pp. 55-64, 2010.
- [18] A. E. Shilov and G. B. Shul'pin, Activation and Catalytic Reactions of Saturated Hydrocarbons in the Presence of Metal Complexes, Kluwer Academic Publishers, London, UK, 2002.